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Indian Standard

AUXILIARY TABLES FOR VIBRATION GENERATORS — METHODS OF DESCRIBING EQUIPMENT CHARACTERISTICS

ICS 17.160

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Price Group 5

Mechanical Vibration and Shock Sectional Committee, LM 04

NATIONAL FOREWORD

This Indian Standard which is identical with ISO 6070:1981 'Auxiliary tables for vibration generators — Methods of describing equipment characteristics' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of Mechanical Vibration and Shock Sectional Committee and approval of the Light Mechanical Engineering Division Council.

The text of ISO Standard has been approved as suitable for publication as Indian Standard without deviations. In the adopted standard certain conventions are not identical to those used in Indian Standard. Attention is especially drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a full point (.) as the decimal marker.

IS 14731 : 1999
ISO 6070 : 1981

Indian Standard

AUXILIARY TABLES FOR VIBRATION GENERATORS — METHODS OF DESCRIBING EQUIPMENT CHARACTERISTICS

1 Scope

This International Standard defines the content of the information flow to be established between manufacturers and users of auxiliary tables with a view to working out related specifications and possibly to comparing in an objective way, the characteristics advertised by the various manufacturers of auxiliary tables and associated guidance systems.

2 Field of application

This International Standard applies to auxiliary tables associated with one or several vibration generators working along axes which are parallel to the longitudinal axis of the table.[1]

The tables dealt with in this International Standard are of the following types :

- flat spring tables;
- oil film or air cushion tables;
- mechanical slide tables;
- ball, roller or needle bearing tables;
- hydraulic slide tables;
- hydrostatic bearing tables;
- magnetic bearing tables;
- dry bearing tables with hydrostatic compensation;

or

- a combination of two or more of the above types.

This International Standard provides three levels of description to be used in describing test equipment, as follows :

a) minimum level of description;

b) medium level of description;

c) high level of description.

This International Standard gives for each level of description a list of the characteristics to be described by the manufacturer either in his tender or in his literature.

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[1] Auxiliary tables with several degrees of freedom are not covered by this International Standard which applies specifically to the more common types of auxiliary tables where the surface of the table is horizontal; however, if suitable means for counteracting the force of gravity are provided, the table may have any orientation.

3 Symbols

C_α	Limiting pitching torque
C_β	Limiting rolling torque
C_ψ	Limiting yawing torque
d	Total harmonic distortion of acceleration
F_a	Force measured in direction z to overcome static (stiction) friction (possibly for various test loads and various positions of the moving table along longitudinal z axis)
F_g	Force measured in direction z to overcome dynamic friction
F_s	Static load limit
$F_x - F_y - F_z$	Limiting forces which can be withstood by the moving auxiliary table along the three axes
f	Frequency
f_{max}	Maximum operational frequency
f_{min}	Minimum operational frequency
$I_x - I_y - I_z$	Moments of inertia of the moving table with respect to axes parallel to the reference axes through the centre of gravity
$K_x - K_y - K_z$	Translational stiffness of guidance system along the three axes
$K_\alpha - K_\beta - K_\psi$	Rotational stiffness of guidance about the three axes
m	Total mass of moving table including moving components of guidance system
m_t	Test load (index t = 0, 1, 2, 3, 4 and 5, see clause 6)
V_z	Rated rms velocity along z axis
$X_C - Y_C - Z_C$	Coordinates of centre of test table surface (see 5.2, figure 2)
$X_G - Y_G - Z_G$	Coordinates of moving table centre of gravity
α	Pitch angle (rotation about y axis)
β	Roll angle (rotation about z axis)
ψ	Yaw angle (rotation about x axis)

4 Units

When the manufacturer, or user, specifies values for the parameters required in this International Standard, the units to be used shall be clearly defined and it shall be stated, where applicable, whether quantities are expressed as rms, peak or peak-to-peak values.

5 Definitions

An auxiliary table is a mechanical system intended for transmitting vibration generated by one or more vibration generators to equipment under test.

The table is fitted with its own guidance system which shall be compatible with the guidance system of the vibration generator(s).

The auxiliary table is composed of :

- the moving table including the test table and the coupling (or couplings) to the vibration generator (or generators);
- the guidance system;
- levelling blocks.

5.1 Types of auxiliary tables

5.1.1 flat spring tables : The connection between the moving table and the fixed part of the guidance system is achieved by metallic flat springs, the stiffness of which is low in the longitudinal direction and high in the other five degrees of freedom.

5.1.2 oil or air cushion tables : The moving table lies on a face plate, the two opposite faces being separated by an oil or grease film or by an air cushion to reduce the friction coefficient. (It is not possible to define the degree of stiffness of the connection between the moving table and the fixed part of the guidance system for this type of table).

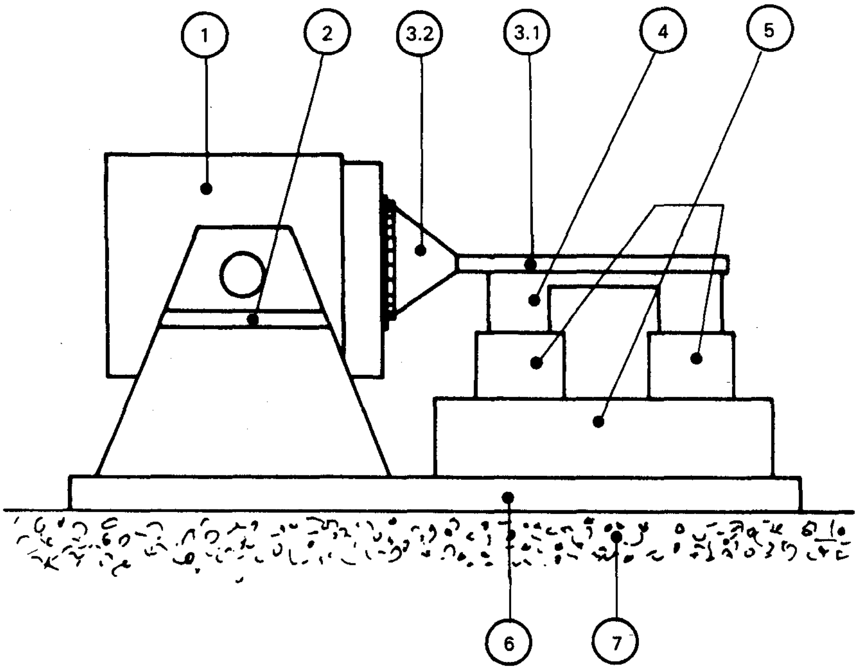
5.1.3 mechanical slide tables : The connection between the fixed part of the guidance system and the moving table is ensured by a system of slides and connecting links. The stiffness is very low in the longitudinal direction. The stiffness for the other degrees of freedom is very high except for any clearances which may exist.

5.1.4 ball, roller or needle bearing tables : The principle is the same as for mechanical slide tables but friction reduction is obtained by ball, roller or needle bearing.

5.1.5 hydraulic slide tables : The principle is the same as for mechanical slide tables but lubrication is achieved under pressure. Stiffness can be defined for very small transverse linear or rotational displacements.

5.1.6 hydrostatic bearing tables : The connection between the table and the fixed parts of the guidance system is achieved by fluid pressure. This ensures self-centering of the system.

Connecting stiffness is negligible in the longitudinal direction. Stiffness corresponding to the other degrees of freedom can be defined.



1 Vibration generator

2 Vibration generator suspension (free or locked)

3 Moving table
  3.1 Test table
  3.2 Coupling

4 Guidance system of moving table

5 Levelling blocks

6 Base plate

7 Foundation

Figure 1 — Example of coupling of an auxiliary table to single vibration generator — Typical arrangement

5.1.7 magnetic bearing tables : The connection between the table and the fixed part of the guidance system is achieved by a magnetic field, the gradient of which determines the stiffness. There is no physical contact between the moving surfaces. Stiffness and friction are negligible in the longitudinal direction. Stiffness corresponding to the other degrees of freedom can be defined.

5.1.8 dry bearing tables with hydrostatic compensation : The connection between the table and the fixed part of the guidance system is achieved by contact of two materials with low-friction properties.

Self-alignment and clearance compensation are ensured by fluid pressure on the outside of the contact surface.

The stiffness is very low in the longitudinal direction. Stiffness corresponding to the other degrees of freedom can be defined.

5.2 Axis systems

5.2.1 moving table reference axis system : The characteristic dimensions of the moving table are defined with respect to the axes constituting its reference axis system (see figure 2).

OZ is the longitudinal axis (parallel to the direction of the motion induced by the vibration generator and directed from the loading surface of the moving table to the free end).

OX is the normal axis (perpendicular to the moving table plane and directed towards the equipment under test).

OY is the lateral axis (constitutes a direct rectangular trihedral angle with the above-mentioned axes).

The origin O of the reference axis system is the intersection of the moving table loading surface with the horizontal axis of the vibration generator.

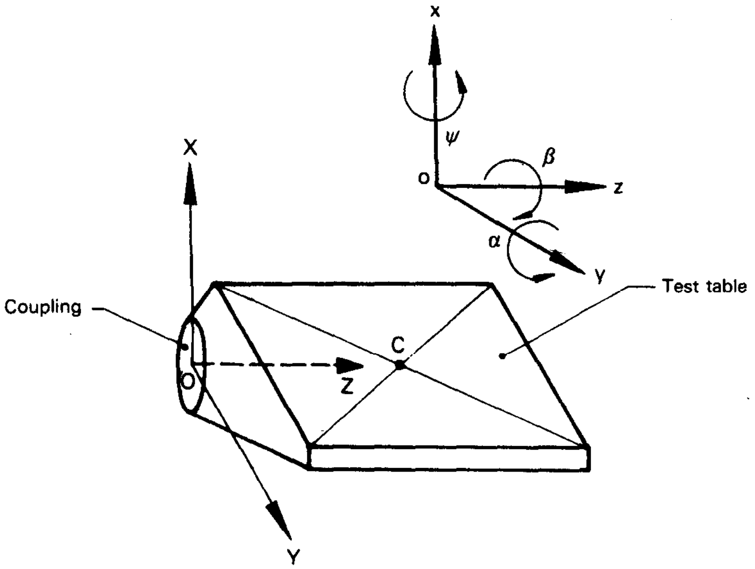


Figure 2 — Moving table reference axis system

In the case where the table is coupled to several vibration generators, one is selected to define the reference axis system for the moving table.

Motions are defined with respect to a fixed axis system ox, oy, oz, the axes of which are parallel to the axes of the moving table reference axis system.

5.2.2 other moving table reference axis systems : Other axis systems whose axes are parallel to the table reference axis system and where the origin is according to requirement (for example, centre of gravity, centre of mounting plane, etc.) can be defined for special purposes.

5.3 Characteristics

5.3.1 effective travel : The limits between which the moving table normally operates and beyond which performances are no longer guaranteed by the manufacturer.

5.3.2 rated frequency range : The limits f_{min} and f_{max} between which the moving table normally operates and below and above which performances are no longer guaranteed by the manufacturer.

5.3.3 rated rms velocity V_z : The rated rms value of the velocity along the z-axis is the maximum value of the velocity for which the table can operate continuously over the rated frequency range with the selected test load (pure mass).

5.3.4 static load (limit) F_s : The maximum static load which can be withstood by the table without damage.

5.3.5 limiting axial forces F_x, F_y, F_z : The limiting axial forces, static as well as dynamic, which can be exerted on the auxiliary table along the three axes without damage.

5.3.6 limiting pitching torque C_α : The limiting torque in pitch due to static and dynamic forces which can be exerted on the table without damage.

5.3.7 limiting rolling torque C_β : The limiting torque in roll due to static and dynamic forces which can be exerted on the table without damage.

5.3.8 limiting yawing torque C_ψ : The limiting torque in yaw due to static and dynamic forces which can be exerted on the table without damage.

NOTE — In the case of moving tables simultaneously driven from several points, the conditions of use shall be agreed between the manufacturer and the user.

5.3.9 transmissibility : The non-dimensional ratio of the response amplitude of a system in steady state forced vibration to the excitation amplitude. The ratio may be one of forces, displacements, velocities or accelerations.

5.3.10 total harmonic distortion of acceleration : Related to the output signal, it is expressed by the following equation :

$$d = \frac{\sqrt{A_2^2 + A_3^2 + \ldots A_n^2}}{\sqrt{A_1^2 + A_2^2 + \ldots A_n^2}} \times 100 \text{ (as a percentage)}$$

in which A_1 represents the value of the fundamental term of the signal and $A_2 \ldots A_n$ the harmonic components of the nth order of the signal.

5.3.11 environmental limits : The upper limits of all environmental conditions, such as ambient temperature, humidity, dust level, etc. below which continuous operation can be achieved. It is suggested that the manufacturer confirm the ambient temperature limit during an endurance test (of 8 h for example) at the rated velocity with the test loads m_t, by measuring temperature in the vicinity of the guidance system to check that the heating effect obtained is not excessive.

6 Test loads m_t

Auxiliary tables are tested using test loads preferably chosen from those recommended in this International Standard or any other load agreed between the manufacturer and the user.

NOTES

1 In order that the natural modes of the system, including the test load and its coupling to the test table, are outside the rated frequency range, the following guidelines should be observed.

- a) fixing screws shall be used in all available mounting locations to ensure sufficient stiffness of connection and avoid loosening or slipping;
- b) attention should be paid to the compatibility between contact surfaces of the test load and test table (for example, as concerns flatness);
- c) a test load of small relative height shall be used. The recommended ratio of the height to the diameter or diagonal of the test load shall be less than or equal to 0,4.

2 If so agreed between the manufacturer and the user, offset test loads can be used, in which case the loads and their fixing shall be defined.

6.1 Test load m_0

The load of the table alone without added mass.

6.2 Test load m_1

A load permitting an acceleration of approximately 40 g_n peak under sinusoidal conditions.

6.3 Test load m_2

A load permitting an acceleration of approximately 10 g_n peak under sinusoidal conditions.

6.4 Test load m_3

A load permitting an acceleration of approximately 4 g_n peak under sinusoidal conditions.

6.5 Test load m_4

A load permitting an acceleration of approximately 1 g_n peak under sinusoidal conditions.

6.6 Test load m_5

A load permitting an acceleration of approximately 20 g_n peak under sinusoidal conditions.

NOTE — This test load m_5 shall be used only when test load m_1 cannot be used because an acceleration of 40 g_n exceeds the capability of the vibration generator. At the option of the manufacturer, data with this load m_5 may be provided wherever this International Standard calls for data with the test load m_1, however such substitution shall be called to the attention of the user by placing the subscript 5 on the symbols for all such data and adding to the page of data the note : Test load m_5 replaces test load m_1.

7 Characteristics to be supplied by the manufacturer

Attention is drawn to the fact that the three levels of description adopted in this International Standard are not related to the quality or size of the auxiliary tables.

A higher level of description may, for example, be required for an auxiliary table of small size and medium quality whereas under certain circumstances, a medium level of description can be sufficient for a large-size, high quality auxiliary table.

The level of description required will normally depend on the use to which the equipment is to be put by the customer.

The characteristics shown by the sign "+" in tables 1 to 9 shall be supplied where demanded by the particular level of description.

Those characteristics which are not required in the tables for the particular level of description (i.e. those which are shown by the sign "–") can however be supplied by agreement between the manufacturer and the user.

NOTE — Attention is drawn to the fact that such characteristics have to be specified at the time of the enquiry and ordering, because their cost, which can be high, has to be taken into consideration.

Clause 8 describes guidelines for measurement for certain dynamic characteristics which may or may not be required by the tables 1 to 9.

7.1 Characteristics shared by all table types

Table 1

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Physical and mechanical characteristics				
Total mass *m* of moving table including moving components of guidance system		+	+	+
Dimensions of test table surface		+	+	+
Coordinates of moving table centre of gravity G		–	+	+
Coordinates of centre (C) of test table surface (see figure 2)	5.2.1	–	+	+
Dimensions of fixing points and tightening torques on test table		+	+	+
Flatness tolerance of the table		–	+	+
Surface flatness of coupling (*s*)		–	+	+
Dimensioned drawing of auxiliary table		+	+	+
Static load limit F_s	5.3.4	+	+	+
Moment of inertia of moving table including moving components of guidance system with respect to an axis parallel to X-axis, through the centre of gravity of the table (I_x)		–	–	–
Moment of inertia of moving table including moving components of guidance system with respect to an axis parallel to Y-axis, through the centre of gravity of the table (I_y)		–	–	–
Moment of inertia of moving table including moving components of guidance system with respect to an axis parallel to Z-axis, through the centre of gravity of the table (I_z)		–	–	–
Operational characteristics				
Rated frequency range	5.3.2	+	+	+
Effective travel	5.3.1	+	+	+
Mechanical stop clearance		+	+	+
Maximum no-load acceleration at point C (along Z-axis)		–	+	+
Limiting axial force F_z	5.3.5	+	+	+
Test table acceleration field uniformity along X-axis	8.3	–	–	–
Test table acceleration field uniformity along Y-axis	8.3	–	–	–
Test table acceleration field uniformity along Z-axis	8.3	–	+	+
First no-load resonance frequency		+	+	+
Parasitic rotation	8.5	–	–	–
(No-load) angular acceleration about X-axis at point C		–	–	–
(No-load) angular acceleration about Y-axis at point C		–	–	–
(No-load) angular acceleration about Z-axis at point C		–	–	–
(Loaded) angular acceleration[1] about X-axis at point C		–	–	–
(Loaded) angular acceleration[1] about Y-axis at point C		–	–	–
Loaded angular acceleration[1] about Z-axis at point C		–	–	–
Total harmonic distortion	8.4	–	+	+
Acceleration transmissibility between point C and point O	8.1	–	–	+
Maximum temperature of moving table		–	–	+

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1) For the various test loads m_l.

Table 1 *(concluded)*

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Characteristics of installation and mounting				
Total mass of auxiliary table		+	+	+
Condition of generator suspension (free or locked)		+	+	+
Operating position (horizontal or vertical)		+	+	+
Environmental conditions to which the auxiliary table may be subjected (temperature, humidity, etc.)		–	+	+
Safety devices		+	+	+
Requirements for installation and operation (for example, water, electrical power, overhead crane.)		+	+	+
Mechanical characteristics of coupling(s)		+	+	+
Coupling compatibility and alignment tolerances between vibration generator and auxiliary tables		+	+	+
Mounting tolerances (specify in particular the distance between point O and the lowest plane of the parts of auxiliary tables being supplied, as well as the associated tolerances)		+	+	+
Heaviest load to be handled		+	+	+
Pollution generated by auxiliary table (for example, oil)		–	–	–
Details of installation (see figure 1)	5			
– levelling block	5	+	+	+
– base plate	5	+	+	+
– foundation	5	+	+	+
Environmental limits	5.3.11	+	+	+

1) For the various test loads m_t.

7.2 Special characteristics for flat spring tables

Table 2

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting lateral force (F_y)	5.3.5	–	–	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Translational stiffness of guidance system along X-axis (K_x)		–	+	+
Translational stiffness of guidance system along Y-axis (K_y)		–	–	+
Translational stiffness of guidance system along Z-axis (K_z)		+	+	+
Rotational stiffness of guidance system about X-axis (K_ψ)		–	–	–
Rotational stiffness of guidance system about Y-axis (K_α)		–	+	+
Rotational stiffness of guidance system about Z-axis (K_β)		–	–	–

7.3 Special characteristics for oil film or air cushion tables

Table 3

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Force to overcome static friction (F_a)		−	+	+

7.4 Special characteristics for mechanical slide tables

Table 4

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting lateral force (F_y)	5.3.5	−	−	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Force to overcome static friction (F_a)		−	+	+

7.5 Special characteristics for ball, roller or needle bearing tables

Table 5

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting lateral force (F_y)	5.3.5	−	−	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Force to overcome static friction (F_a)		−	+	+
Translational stiffness of guidance system along X-axis (K_x)		−	+	+
Translational stiffness of guidance system along Y-axis (K_y)		−	−	+
Rotational stiffness of guidance system about X-axis (K_ψ)		−	−	−
Rotational stiffness of guidance system about Y-axis (K_α)		−	+	+
Rotational stiffness of guidance system about Z-axis (K_β)		−	−	−

7.6 Special characteristics for hydraulic slide tables

Table 6

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting lateral force (F_y)	5.3.5	−	−	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Force to overcome static friction (F_a)		−	+	+

7.7 Special characteristics for hydrostatic bearing tables

Table 7

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting lateral force (F_y)	5.3.5	–	–	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Force to overcome static friction (F_a)		–	+	+
Translational stiffness of guidance system along X-axis (K_x)		–	+	+
Translational stiffness of guidance system along Y-axis (K_y)		–	–	+
Rotational stiffness of guidance system about X-axis (K_ψ)		–	–	–
Rotational stiffness of guidance system about Y-axis (K_α)		–	+	+
Rotational stiffness of guidance system about Z-axis (K_β)				

7.8 Special characteristics for magnetic bearing tables

Table 8

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Limiting lateral force (F_y	5.3.5	–	–	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Translational stiffness of guidance system along X-axis (K_x)		–	+	+
Translational stiffness of guidance system along Y-axis (K_y)		–	–	+
Rotational stiffness of guidance system about X-axis (K_ψ)		–	–	–
Rotational stiffness of guidance system about Y-axis (K_α)		–	+	+
Rotational stiffness of guidance system about Z-axis (K_β)		–	–	–

7.9 Special characteristics for dry bearing tables with hydrostatic compensation

Table 9

Characteristics	Reference to corresponding clause	Level of description		
		minimum	medium	high
Rated velocity (V_z)	5.3.3	+	+	+
Limiting lateral force (F_y)	5.3.5	–	–	+
Limiting pitching torque (C_α)	5.3.6	+	+	+
Force to overcome static friction (F_a)		–	+	+
Translational stiffness of guidance system along X-axis (K_x)		–	+	+
Translational stiffness of guidance system along Y-axis (K_y)		–	–	+
Rotational stiffness of guidance system about X-axis (K_ψ)		–	–	–
Rotational stiffness of guidance system about Y-axis (K_α)		–	+	+
Rotational stiffness of guidance system about Z-axis (K_β)		–	–	–

8 Measurement of common dynamic characteristics

8.1 Plotting of the acceleration transmissibility function

The transmissibility between the vibration generator and a point placed as close as possible to the central point (C) of the auxiliary table is determined as a function of frequency (see figure 2).

NOTE — The reference accelerometer shall be placed on the vibration generator as close as possible to the origin of the reference axis system of the auxiliary table and threaded insert used.

8.2 Measurement of transverse accelerations

8.2.1 Under no-load conditions

Transverse accelerations are measured using a tri-axial accelerometer placed as close as possible to the central point (C) of the table. It is fundamental that the three transducers be fixed at the same point.

8.2.2 Under loaded conditions

The same conditions of measurement as above apply, but using a test load selected from those defined in clause 6.

8.3 Measurement of test table acceleration field uniformity

This operation consists in determining the no-load transmissibility between an accelerometer placed as close as possible to point C and several transducers positioned normally to the threaded inserts used for fixing equipment under test as a function of frequency. The sensitive axis of the accelerometers shall be directed along the axis considered for the measurement.

NOTE — In the case of measurement along axis ox, evidence of table deformations can be shown in a simple and rapid way using the Chladni method. This procedure consists of spreading on the table a fine powder which makes nodal lines appear when subjected to vibration.

8.4 Measurement of acceleration distortion

The distortion shall be measured under no-load conditions at the rated characteristics of the table in the rated frequency range.

NOTES

1 Some instruments measure the total harmonic distortion d by suppressing the fundamental acceleration, and noise is then present; in this case, the ratio of the total harmonic distortion to the background noise expressed as a percentage of the rated output voltage must be at least 10 dB.

2 The total harmonic distortion d can also be calculated by summing up the values of the harmonic distortion of the nth order according to the "square law" (see IEC Publication 268-3[1]).

3 Since the acceleration distortion depends on the characteristics of both the auxiliary table and the vibration generator, the manufacturer shall supply a description of the vibration generator used to drive the auxiliary table, including its armature mass and no-load distortion.

8.5 Measurement of parasitic rotations

For very special applications (for example, the study of vibrating gyroscopes) it is necessary to know the rotation of the table about each of the three axes of the axis system ox, oy, oz.

This measurement can be carried out by an optical procedure with mirrors incorporated in the table.

9 Operating instructions

The manufacturer shall supply instructions for the operation, maintenance and adjustment of the auxiliary table. They shall include the following :

a) principles;

b) description of the auxiliary table;

c) method of operation;

d) mounting plane;

e) diagram of the service connections;

f) cable diagram;

g) installation conditions;

h) assembling and dismantling instructions;

j) list of special tools, if required;

k) nomenclature;

m) preferred list of spare parts recommended by the manufacturer;

n) miscellaneous.

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[1] IEC Publication 268-3, *Sound system equipment. Part 3 : Sound system amplifiers.*

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